



**CHEMISTRY
HIGHER LEVEL
PAPER 1**

Wednesday 17 November 2004 (afternoon)

1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.

1. Consider the following equation.



How many moles of $\text{CO}_2(\text{g})$ are produced by the complete combustion of 58 g of butane, $\text{C}_4\text{H}_{10}(\text{g})$?

- A. 4
B. 8
C. 12
D. 16
2. 6.0 moles of $\text{Fe}_2\text{O}_3(\text{s})$ reacts with 9.0 moles of carbon in a blast furnace according to the equation below.



What is the limiting reagent and hence the theoretical yield of iron?

	Limiting reagent	Theoretical yield of iron
A.	Fe_2O_3	6.0 mol
B.	Fe_2O_3	12.0 mol
C.	carbon	9.0 mol
D.	carbon	6.0 mol

3. What volume of $0.500 \text{ mol dm}^{-3}$ $\text{HCl}(\text{aq})$ is required to react completely with 10.0 g of calcium carbonate according to the equation below?



- A. 100 cm^3
B. 200 cm^3
C. 300 cm^3
D. 400 cm^3

4. A certain sample of element Z contains 60% of ^{69}Z and 40% of ^{71}Z . What is the relative atomic mass of element Z in this sample?
- A. 69.2
B. 69.8
C. 70.0
D. 70.2
5. Which ion would undergo the greatest deflection in a mass spectrometer?
- A. $^{16}\text{O}^+$
B. $^{16}\text{O}^{2+}$
C. $^{18}\text{O}^{2+}$
D. $(^{16}\text{O}^{18}\text{O})^+$
6. Rubidium is an element in the same group of the periodic table as lithium and sodium. It is likely to be a metal which has a
- A. high melting point and reacts slowly with water.
B. high melting point and reacts vigorously with water.
C. low melting point and reacts vigorously with water.
D. low melting point and reacts slowly with water.
7. When the following species are arranged in order of **increasing** radius, what is the correct order?
- A. Cl^- , Ar , K^+
B. K^+ , Ar , Cl^-
C. Cl^- , K^+ , Ar
D. Ar , Cl^- , K^+

8. The cyanide ion, CN^- , can form two complex ions with iron ions. The formulas of these ions are $[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{Fe}(\text{CN})_6]^{3-}$. What is the oxidation state of iron in the two complex ions?

	$[\text{Fe}(\text{CN})_6]^{4-}$	$[\text{Fe}(\text{CN})_6]^{3-}$
A.	– 4	– 3
B.	+2	+3
C.	+3	+2
D.	– 3	– 4

9. Which molecule is linear?

- A. SO_2
- B. H_2S
- C. CO_2
- D. Cl_2O

10. Why is the boiling point of PH_3 lower than that of NH_3 ?

- A. PH_3 is non-polar whereas NH_3 is polar.
- B. PH_3 is not hydrogen bonded whereas NH_3 is hydrogen bonded.
- C. Van der Waals' forces are weaker in PH_3 than in NH_3 .
- D. The molar mass of PH_3 is greater than that of NH_3 .

11. Which molecule is non-polar?

- A. H_2CO
- B. CHCl_3
- C. NF_3
- D. SO_3

12. NO_3^- is trigonal planar and NH_3 is trigonal pyramidal. What is the approximate hybridization of N in each of these species?

	N in NO_3^-	N in NH_3
A.	sp^2	sp^3
B.	sp^2	sp^2
C.	sp^3	sp^2
D.	sp^3	sp^3

13. Consider the following statements.

- I. All carbon-oxygen bond lengths are equal in CO_3^{2-} .
- II. All carbon-oxygen bond lengths are equal in CH_3COOH .
- III. All carbon-oxygen bond lengths are equal in CH_3COO^- .

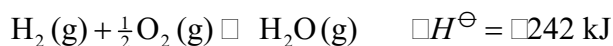
Which statements are correct?

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

14. The temperature in Kelvin of 2.0 dm^3 of an ideal gas is doubled and its pressure is increased by a factor of four. What is the final volume of the gas?

- A. 1.0 dm^3
- B. 2.0 dm^3
- C. 3.0 dm^3
- D. 4.0 dm^3

15. Consider the following equations.



What is the ΔH^\ominus value (in kJ) for the following reaction?



- A. -844
 - B. -360
 - C. $+360$
 - D. $+844$
16. For which of the following is the sign of the enthalpy change different from the other three?
- A. $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO(s)} + \text{CO}_2(\text{g})$
 - B. $\text{Na(g)} \rightarrow \text{Na}^+(\text{g}) + \text{e}^-$
 - C. $\text{CO}_2(\text{s}) \rightarrow \text{CO}_2(\text{g})$
 - D. $2\text{Cl(g)} \rightarrow \text{Cl}_2(\text{g})$

17. Separate solutions of HCl(aq) and $\text{H}_2\text{SO}_4\text{(aq)}$ of the same concentration and same volume were completely neutralized by NaOH(aq) . X kJ and Y kJ of heat were evolved respectively. Which statement is correct?
- A. $X = Y$
 - B. $Y = 2X$
 - C. $X = 2Y$
 - D. $Y = 3X$
18. The enthalpy change, ΔH^\ominus , for a chemical reaction is -10 kJ mol^{-1} and the entropy change, ΔS^\ominus , is $-10 \text{ J K}^{-1} \text{ mol}^{-1}$ at 27°C . What is the value of ΔG^\ominus (in J) for this reaction?
- A. -260
 - B. -7000
 - C. -9730
 - D. -13000
19. For a given reaction, why does the rate of reaction increase when the concentrations of the reactants are increased?
- A. The frequency of the molecular collisions increases.
 - B. The activation energy increases.
 - C. The average kinetic energy of the molecules increases.
 - D. The rate constant increases.

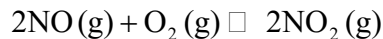
20. Consider the following statements.

- I. The rate constant of a reaction increases with increase in temperature.
- II. Increase in temperature decreases the activation energy of the reaction.
- III. The term A in the Arrhenius equation ($k = Ae^{\frac{-E_a}{RT}}$) relates to the energy requirements of the collisions.

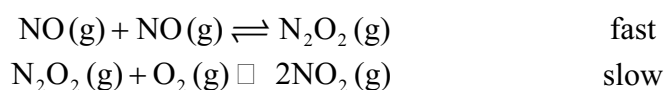
Which statement(s) is/are correct?

- A. I only
- B. II only
- C. I and III only
- D. II and III only

21. For the chemical reaction



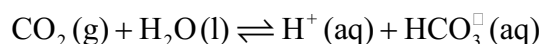
the following reaction mechanism has been proposed.



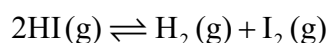
What could be the rate equation for this reaction?

- A. $\text{rate} = k[\text{NO}][\text{O}_2]$
- B. $\text{rate} = k[\text{NO}]^2$
- C. $\text{rate} = k[\text{N}_2\text{O}_2][\text{O}_2]$
- D. $\text{rate} = k[\text{NO}]^2[\text{O}_2]$

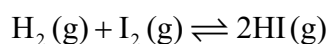
22. What will happen if $\text{CO}_2(\text{g})$ is allowed to escape from the following reaction mixture at equilibrium?



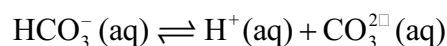
- A. The pH will decrease.
 - B. The pH will increase.
 - C. The pH will remain constant.
 - D. The pH will become zero.
23. The value of the equilibrium constant for the reaction



is 0.25 at 440°C . What would the value of the equilibrium constant be for the following reaction at the same temperature?



- A. 0.25
 - B. 0.50
 - C. 2.0
 - D. 4.0
24. Consider the following equilibria in 0.10 mol dm^{-3} carbonic acid.



Which species is present in the highest concentration?

- A. $\text{H}_2\text{CO}_3(\text{aq})$
- B. $\text{H}^+(\text{aq})$
- C. $\text{HCO}_3^-(\text{aq})$
- D. $\text{CO}_3^{2-}(\text{aq})$

25. The acid dissociation constant of a weak acid HA has a value of $1.0 \times 10^{-5} \text{ mol dm}^{-3}$. What is the pH of a 0.10 mol dm^{-3} aqueous solution of HA?
- A. 2
- B. 3
- C. 5
- D. 6
26. Which mixture would produce a buffer solution when dissolved in 1.0 dm^3 of water?
- A. 0.50 mol of CH_3COOH and 0.50 mol of NaOH
- B. 0.50 mol of CH_3COOH and 0.25 mol of NaOH
- C. 0.50 mol of CH_3COOH and 1.00 mol of NaOH
- D. 0.50 mol of CH_3COOH and 0.25 mol of $\text{Ba}(\text{OH})_2$
27. Which compound, when dissolved in aqueous solution, has the highest pH?
- A. NaCl
- B. Na_2CO_3
- C. NH_4Cl
- D. NH_4NO_3
28. In which reaction is $\text{H}_2\text{PO}_4^- (\text{aq})$ acting as a Brønsted-Lowry base?
- A. $\text{H}_2\text{PO}_4^- (\text{aq}) + \text{NH}_3 (\text{aq}) \rightleftharpoons \text{HPO}_4^{2-} (\text{aq}) + \text{NH}_4^+ (\text{aq})$
- B. $\text{H}_2\text{PO}_4^- (\text{aq}) + \text{OH}^- (\text{aq}) \rightleftharpoons \text{HPO}_4^{2-} (\text{aq}) + \text{H}_2\text{O} (\text{l})$
- C. $\text{H}_2\text{PO}_4^- (\text{aq}) + \text{C}_2\text{H}_5\text{NH}_2 (\text{aq}) \rightleftharpoons \text{HPO}_4^{2-} (\text{aq}) + \text{C}_2\text{H}_5\text{NH}_3^+ (\text{aq})$
- D. $\text{H}_2\text{PO}_4^- (\text{aq}) + \text{CH}_3\text{COOH} (\text{aq}) \rightleftharpoons \text{H}_3\text{PO}_4 (\text{aq}) + \text{CH}_3\text{COO}^- (\text{aq})$

29. Consider the following reaction.



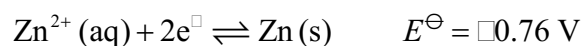
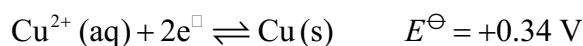
Which statement is correct?

- A. H_2SO_3 is the reducing agent because it undergoes reduction.
- B. H_2SO_3 is the reducing agent because it undergoes oxidation.
- C. Sn^{4+} is the oxidizing agent because it undergoes oxidation.
- D. Sn^{4+} is the reducing agent because it undergoes oxidation.

30. What happens at the positive electrode in a voltaic cell and in an electrolytic cell?

	Voltaic cell	Electrolytic cell
A.	Reduction	Oxidation
B.	Oxidation	Reduction
C.	Oxidation	Oxidation
D.	Reduction	Reduction

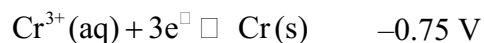
31. Consider the following reactions.



Which statement is correct?

- A. $\text{Cu}^{2+}(\text{aq})$ will oxidize both $\text{Mg}(\text{s})$ and $\text{Zn}(\text{s})$.
- B. $\text{Zn}(\text{s})$ will reduce both $\text{Cu}^{2+}(\text{aq})$ and $\text{Mg}^{2+}(\text{aq})$.
- C. $\text{Mg}^{2+}(\text{aq})$ will oxidize both $\text{Cu}(\text{s})$ and $\text{Zn}(\text{s})$.
- D. $\text{Cu}(\text{s})$ will reduce both $\text{Mg}^{2+}(\text{aq})$ and $\text{Zn}^{2+}(\text{aq})$.

32. Consider the standard electrode potentials of the following reactions.



What is the value of the cell potential (in V) for the following reaction?



- A. -0.35
- B. -1.15
- C. $+0.30$
- D. $+0.35$
33. Aqueous solutions containing different concentrations of NaCl were electrolysed using platinum electrodes. What is the **major** product at the positive electrode in each case?

	0.001 mol dm⁻³ NaCl(aq)	1.0 mol dm⁻³ NaCl(aq)
A.	H ₂	Na
B.	H ₂	H ₂
C.	O ₂	Cl ₂
D.	Cl ₂	O ₂

34. Which compound has the lowest boiling point?

- A. CH₃CH₂CH(CH₃)CH₃
- B. (CH₃)₄C
- C. CH₃CH₂CH₂CH₂CH₃
- D. CH₃CH₂OCH₂CH₃

35. Which species will show optical activity?

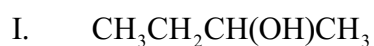
- A. 1-chloropentane
- B. 3-chloropentane
- C. 1-chloro-2-methylpentane
- D. 2-chloro-2-methylpentane

36. What type of reaction does the equation below represent?



- A. substitution
- B. condensation
- C. reduction
- D. addition

37. Consider the following compounds.



The compounds are treated separately with acidified potassium dichromate(VI) solution. Which will produce a colour change from orange to green?

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

38. Which compound reacts most rapidly by a S_N1 mechanism?
- A. $(CH_3)_3CCl$
 - B. $CH_3CH_2CH_2CH_2Br$
 - C. $(CH_3)_3CBr$
 - D. $CH_3CH_2CH_2CH_2Cl$
39. Which compound shows three different environments for hydrogen atoms in the 1H NMR spectrum?
- A. $CH_3CH_2CH_3$
 - B. CH_2OHCH_2OH
 - C. $CH_3CH_2CH_2OH$
 - D. $CH_3CH(OH)CH_3$
40. Which statement is correct regarding the structure of benzene?
- A. The 1H NMR spectrum of benzene shows six different environments for H atoms.
 - B. Benzene is a symmetrical, planar molecule with three single and three double bonds.
 - C. The enthalpy change for the hydrogenation of benzene is less exothermic than that of cyclohexatriene.
 - D. Benzene undergoes addition reactions more readily than substitution reactions.
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